Course Outline

ECE 4530 – Parallel Processing

Fall 2025

Instructor

- Prof. Vladimir Okhmatovski, P.Eng.
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  (204) 480–1432
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- *Include "ECE 4530" in the subject line of all correspondence.*

Office Hours

- By appointment.

Teaching Assistant

- Devin Aluthge
  aluthged@myumanitoba.ca
- Andrew Stoyko
  stoykoa@myumanitoba.ca

Contact Hours

- 4 credit hours
- Lectures:
  3 hours x 13 weeks = 39 hours
- Laboratories:
  3 hours x 5 weeks = 15 hours

Prerequisites:

- ECE 2400 Engineering Algorithms 1 (or ECE 3790 Engineering Algorithms) and COMP 2140 Data Structures and Algorithms

OR

- ECE 2240 Numerical Methods for Electrical Engineers and ECE 3730 Principles of Embedded System Design

Traditional Territories Acknowledgement

The University of Manitoba campuses and research spaces are located on original lands of Anishinaabeg, Ininiwak, Anisininewuk, Dakota Oyate, Dene and Inuit, and on the National Homeland of the Red River Métis.

We respect the Treaties that were made on these territories, we acknowledge the harms and mistakes of the past, and we dedicate ourselves to move forward in partnership with Indigenous communities in a spirit of Reconciliation and collaboration.

Course Objectives

The objectives of this course are to introduce students to High-Performance Computing (HPC) and to give students the ability to understand, analyze, design and implement parallel software solutions. Students will develop skills in writing message-passing parallel codes for accelerating computational problems. Core concepts such as parallel efficiency and load balancing will be covered. The course features detailed analysis of effective techniques for parallel processing of inherently parallel problems and provides a foundation for critically analyzing current and future HPC solutions. Additionally, General Purpose Graphics Processing Units (GPGPUs) will be introduced as parallel co-processors.

Course Content

The following topics will be covered:

- Basic parallel computer architectures
- Distributed parallel computing using the Message-Passing Interface (MPI)
- Shared memory parallel computing using OpenMP
- Evaluating parallel programs
- Partitioning strategies
- Load balancing
- Algorithms and applications
- Co-processor acceleration using GPGPUs

Laboratories

There will be five labs covering the following topics:

1. Point-to-point and collective communication using MPI
2. Embarrassingly parallel computations
3. Divide-and-conquer computations
4. Synchronous computations
5. GPGPU computing

Textbook

Programming Massively Parallel Processors: A Hands-on Approach, D. B. Kirk and W. W. Hwu, 3rd Edition, Morgan Kaufmann, 2017. [Not required.]

Academic Integrity

Students are expected to conduct themselves in accordance with the highest ethical standards of the Profession of Engineering and evince academic integrity in all their pursuits and activities at the university. As such, in accordance with the *General Academic Regulations on Academic Integrity* 🔗, students are reminded that plagiarism or any other form of cheating in examinations, term tests, assignments, projects, or laboratory reports is subject to serious academic penalty (e.g. suspension or expulsion from the faculty or university). This includes the unauthorized use of AI when preparing course deliverables. A student found guilty of contributing to cheating by another student is also subject to serious academic penalty. Integrity also applies to respecting copyrighted course content, which should not be distributed without the creator's permission. Uploading content for the purpose of transcription or other AI-enabled features is commonly a violation of the copyright holder's rights.

Copyright Notice

Important Dates

- **Term Test**
  October 30th, 2025
  6:00PM – 8:00PM
- **Voluntary Withdrawal Deadline**
  November 18th, 2025
- **National Day for Truth and Reconciliation**
  September 30th, 2025
  No classes or examinations
- **Thanksgiving Day**
  October 13th, 2025
  No classes or examinations
- **Remembrance Day**
  November 11th, 2025
  No classes or examinations
- **Fall Term Break**
  November 10th –14th, 2025
  No classes or examinations

Accreditation Details

Accreditation Units

- Mathematics: 0%
- Natural Science: 0%
- Complementary Studies: 0%
- Engineering Science: 65%
- Engineering Design: 35%

Graduate Attributes

KB: A knowledge base for engineering
PA: Problem analysis
IN: Investigation
DE: Design
ET: Use of engineering tools
IT: Individual and team work
CS: Communication skills
PR: Professionalism
IE: Impact of engineering on society/ environment
EE: Ethics and equity
EP: Economics and project management
LL: Life-long learning

Competency Levels

I - Introduced (Introductory)
D - Developed (Intermediate)
A - Applied (Advanced)

Learning Outcomes

1. A working knowledge of the Message-Passing Interface (MPI) and its use in parallel software solutions.
2. The ability to analyze a problem and to design and implement parallel strategies for its solution with an emphasis on the trade-offs between time and memory efficiency.
3. Experience with various types of parallelization patterns/algorithms (divide-and-conquer, pipeline, load-balancing) and their application to real-world large-scale engineering computations and software.
4. Familiarity with different parallel hardware architectures (distributed/cluster computing, shared memory systems, and heterogeneous parallel systems) and their influence on parallel software design decisions.
5. The ability to apply parallel programming concepts and skills to emerging and future high-performance computing systems.

Expected Competency Levels

Outcome	KB	PA	IN	DE	ET	IT	CS	PR	IE	EE	EP	LL
1	I	D		D	D							
2	D	D	D	A		A	A					
3	D	D	D	A	A	A	A					
4	I	I	I	I								
5	I	D	D	D	D							D

Evaluation

The final course grade is determined by the student's performance on assignments, in laboratories, and on examinations. Students must complete all laboratories and receive a passing grade on the final examination in order to be eligible to receive a passing grade.

Component	Value (%)	Method of Feedback	Learning Outcomes Evaluated
Assignments	10	F, S	1, 2, 3
Laboratories	25	F, S	1, 2, 3, 5
Term Test	20	F, S	1, 2, 3, 4
Final Examination	45	S	1, 2, 3, 4, 5

∗ Method of Feedback: **F** - Formative (written comments and/or oral discussion), **S** - summative (numerical grade)

CEAB Graduate Attributes Assessed

KB.4 – Recalls and defines, and/or comprehends and applies, first principles and concepts in specialized engineering science.

PA.3 – Analyzes and solves complex engineering problems.

Student Absences

Attendance in lectures, tutorials, and laboratories is mandatory. For short-term absences due to illness or other extenuating circumstances of 120 hours (5 days) or less, students are required to complete a *Self-Declaration Form for Brief or Temporary Absence* available on the University website.🔗 This form must be submitted to the course instructor within 48 hours of the absence. (No additional documentation is required.)
Note that students are responsible to complete any missed work and must consult with the instructor to make appropriate arrangements.
For absences longer than 120 hours, students must contact the instructor and ECE Undergraduate Advisor, Tammy Holowachuk (Tammy.Holowachuk@umanitoba.ca) for further instructions.

Grading Scale

Letter	Mark
A+	95–100
A	85–94
B+	80–84
B	70–79
C+	65–69
C	55–64
D	45–54
F	< 45

Note: These boundaries represent a guide for the instructor and class alike. Provided that no individual student is disadvantaged, the instructor may vary any of these boundaries to ensure consistency of grading from year-to-year.

Deferred Final Examinations

Students who miss the regular scheduled writing of a final examination, for valid medical or compassionate reasons, may be given the opportunity to write a deferred examination, subject to approval by the Associate Dean (Undergraduate). All requests for a deferred examination must be made within 48 hours of the missed examination, and must follow the procedure described on the Faculty website, without exception. Course instructors do not have the discretion to grant deferred final examinations. (https://umanitoba.ca/engineering/student-experience#engineering-student-policies)

Requirements and Regulations

- Attendance at lectures and laboratories is essential for successful completion of this course. Students must satisfy each evaluation component in the course to receive a final grade.
- It is the responsibility of each student to contact the instructor in a timely manner if he or she is uncertain about his or her standing in the course and about his or her potential for receiving a failing grade. Students should also familiarize themselves with the University's *General Academic Regulations*, as well as Section 3 of the Faculty of Engineering *Academic Regulations* dealing with incomplete term work, deferred examinations, attendance and withdrawal.
- No programmable devices or systems (such as calculators, PDAs, iPods, iPads, cell phones, wireless communication or data storage devices) are allowed in examinations unless approved by the course instructor.
- Students should be aware that they have access to an extensive range of resources and support organizations. These include Academic Resources, Counselling, Advocacy and Accessibility Offices as well as documentation of key University policies e.g. Academic Integrity, Respectful Behaviour, Examinations and related matters.

Supplemental Resources

Retention of Student Work

Students are advised that copies of their work submitted in completing course requirements (i.e. assignments, laboratory reports, project reports, test papers, examination papers, etc.) may be retained by the instructor and/or the department for the purpose of student assessment and grading, and to support the ongoing accreditation of each Engineering program. This material shall be handled in accordance with the University's *Intellectual Property Policy* and the protection of privacy provisions of *The Freedom of Information and Protection of Privacy Act (Manitoba)*. Students who do not wish to have their work retained must inform the Head of Department, in writing, at their earliest opportunity.